Intel® Embedded Compact Extended Form Factor Single Board Computer Interface

Specification White Paper

October 2005

Order Number 307466-001

Contents

Figures

Tables

Revision History

Date	Revision	Description
October 2005	1.0	Finalized with industry feedback.
June 2005	0.75	Feedback consolidated. Updated C-Region with option types. New Thermal Enabling content.
March 2005	0.5	Initial draft.

1 Abstract

The single board computer (SBC) small form factor solution has become increasingly important for meeting the challenges of the embedded environment. This document serves both as an open standard form factor specification reference, and a white paper discussion of a proof-of-concept board.

2 Introduction

2.1 Overview

The Intel® Embedded Compact Extended Form Factor (Intel® ECX Form Factor) is an embedded, non-standard body, open standard, small form factor (SFF) single board computer. It is one of the industry's smallest and most widely adopted SBC form factors.

The dimensions of the Intel® ECX Form Factor SBC are 105 mm x 146 mm.

The specifications in this document have been developed to provide an SBC interface to facilitate fast adoption of the Intel low voltage (LV) and ultra-low voltage (ULV) processors onto a small form factor.

This specification is meant to serve as a general guideline. Intel recommends that board designers perform extensive in-house electrical and signal analysis.

This specification describes the mechanical and electrical interfaces, form factor design dimensions, and regions for placement of major components so that hardware vendors and system integrators can build and integrate compliant components, systems, and devices.

This document also describes a proof-of-concept (POC) board that was specifically developed to provide IT professionals the opportunity to evaluate Intel small system solutions, and facilitate rapid time-to-market with customization from board vendors.

The Intel® Embedded Compact Extended Form Factor SBC specification is written and published as an open specification for industry reference. It is expected that embedded hardware vendors may benefit from the reference design by leveraging onto other industry-available small form factor designs.

2.2 Definition of Terms

Table 1. Terms and Acronyms

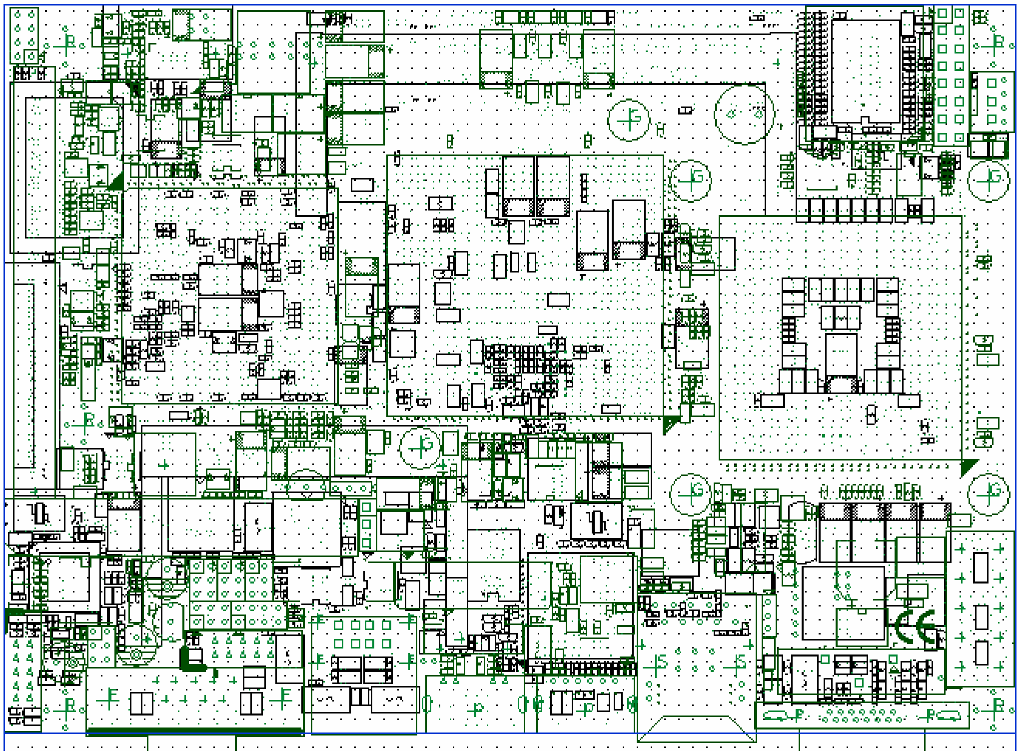
Term	Description
CFM	Cubic Feet per Minute
LFM	Linear Feet per Minute
LPC	Low Pin Count Interface
LV	Low Voltage
PCB	Printed Circuit Board
POS	Point of Sales
SFF	Small Form Factor
ULV	Ultra Low Voltage
Active Heat Sink	Heat sink utilizes convection approach mainly, with air flow provided by attached fan.
Passive Heat Sink	Heat sink utilizes convection approach mainly, with air flow provided by system or chassis fan.

3 Form Factor Overview

3.1 Form Factor Features and Benefits

The Intel® Embedded Compact Extended Form Factor measures 105 x 146 mm. It is a highly integrated single board computer concept with rich generic I/O connections and interfaces. This ultra-compact system allows system integrators to leverage their ideas onto a compact system solution space targeted at a variety of market segments.

Figure 1. Intel® ECX Form Factor SBC Overview



Its size and compact I/O interfaces enable the form factor to fit into a standard DIN slot for use in vehicle infotainment systems, medical imaging systems, portable point-of-sales (POS) systems, panel PCs for industrial use, compact information stations, entertainment, gaming, and other computation-intensive embedded systems.

The nature of embedded systems also requires a great level of I/O flexibility to meet the expansion needs of a particular application. While maintaining its basic single board computer function, a dedicated I/O region is defined in the form factor to provide the greatest flexibility to accommodate expansion needs.

Powered by Intel Low Voltage or Ultra-Low Voltage processors, the Intel® ECX Form Factor delivers high computation power to address various application needs. Intel has enabled multiple thermal solutions for the system to accommodate both system cooling and a *fanless* (natural convection) operating environment. Therefore, the form factor can be implemented both with and without a system fan, depending on the intended environment.

Table 2. Form Factor Features and Benefits

Feature	Benefit
Base Board Geometry	105 mm x 146 mm
Compact I/O Region on Basic Board	Rear panel region defined to accommodate basic I/O interfaces.
Expansion Region	Multiple signal groups defined to address different expansion needs.

3.2 Form Factor Applications

There are many potential market segments which can benefit from the Intel® ECX Form Factor SBC because of its aggressive real estate management, computing performance, and legacy interfaces, as well as its expandability to meet the industry's evolution toward PCI Express* technology. The Intel® ECX Form Factor offers ease of customization to most entry or mid-level computing applications. Two of these market segments are described in more detail below.

Vehicle Infotainment Systems

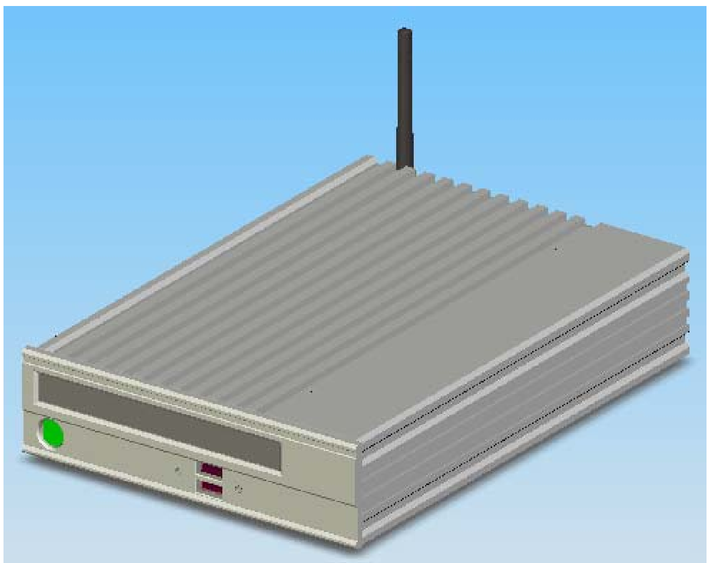
Intel has implemented the Intel® ECX Form Factor SBC on a proof-of-concept board for an on-vehicle infotainment application. (Refer to details on I/O configurations in Section 5.)

Within a 1 DIN height vehicle enclosure standard, the system is able to operate in a fanless environment, utilizing an Intel® Ultra Low Voltage processor.

Different GPS modules on the market today can easily fit onto the board's I/O interface, whether based on the COMM or USB interface.

Wireless network access can be enabled through the expansion region defined in the form factor.

Figure 2. Proof-of-Concept Board in System Solution



Medical Platforms

System solutions for medical rooms, which require a quiet environment, can utilize the form factor's fanless configuration. At the same time, solutions based on Intel Ultra Low Voltage processors can meet the extra processing demands of the shift from traditional film to digital x-rays. The form factor's extremely compact mechanical size allows systems based on it to fit into highly constrained areas.

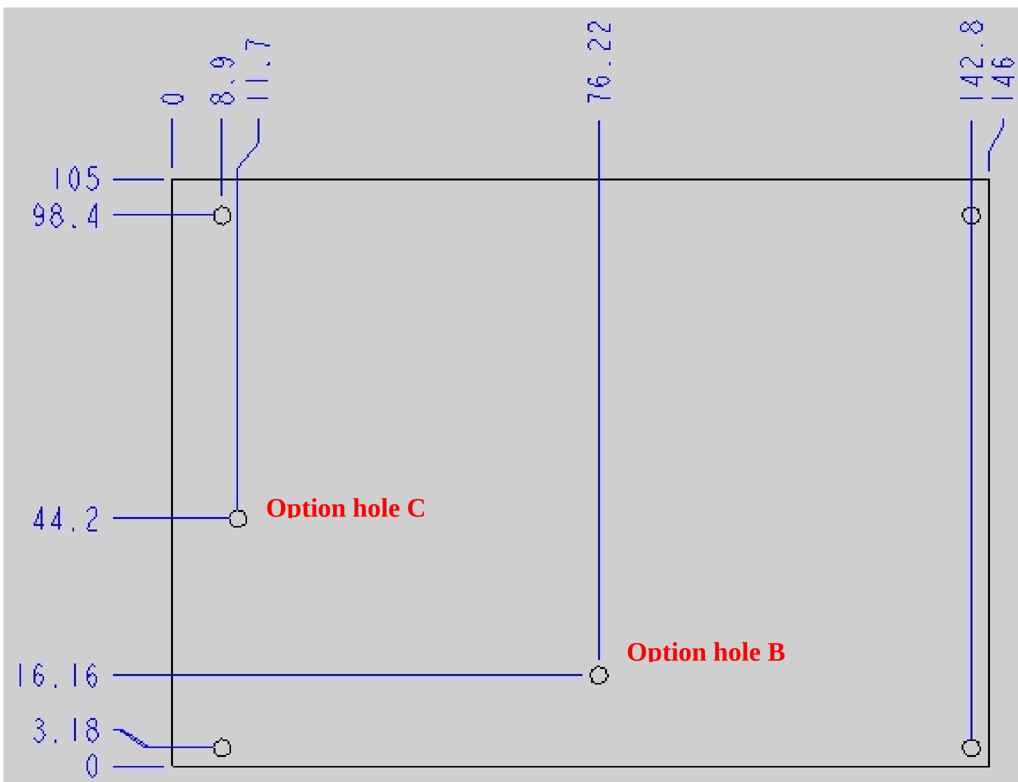
4 Specification Requirements

The following subsections describe the mechanical requirements of the Intel® Embedded Compact Extended Form Factor SBC.

4.1 Board Dimensions and Mounting Holes

In the illustration below, all numbers given are in millimeters.

Figure 3. Board Dimensions and Mounting Holes



The specification defines two types of mounting holes: chassis mounting holes and option holes, to address expansion card support requirements.

Table 3. Platform Mounting Holes

Mounting Hole	Requirements and Justifications
Chassis	The four chassis mounting holes at the edge are required.
Option Hole C	Option hole C is defined in the C-Region (see Figure 4 on page 11). It is defined as an option hole to address the retention mechanism needed by a small expansion card, if such a card is used.
Option Hole B	Option hole B is defined in the B-Region (see Figure 4 on page 11). It is defined as an option hole to address the retention mechanism needed by an “L” shaped expansion card, if such a card is used.

4.2 Form Factor Volumetric Keep-In

This section defines the footprint constraints that comprise the overall form factor volumetric keep-in.

Table 4. Volumetric Categories and Rules

Category	Examples	Rules
Board Components	Memory modules, processors, rear panel I/O connectors and mating cable connectors, component heat sinks, components soldered to board.	Recommended to fit around the board volumetric keep-ins.
System Components	Disk drives, mounting brackets, and system power supply.	Must not intersect the board volumetric keep-in at any point. In addition, should provide adequate clearance between installed system components and the board volumetric keep-in to avoid component interference and/or damage during shipping or other dynamic conditions.
Transition Components	Expansion card/PCB, cabling from board to system components.	May cross the outer boundary of the board volumetric keep-in. May have their own mechanical specifications that should be considered and adhered to by designers, in addition to the specifications in this document.

Primary (Top) Side

The illustration below shows regions defined on the board's primary side. Table 5 and Table 6 describe these regions in more detail.

Please refer to Section 4.1 for option holes requirements and justifications.

Figure 4. Form Factor Region Mapping

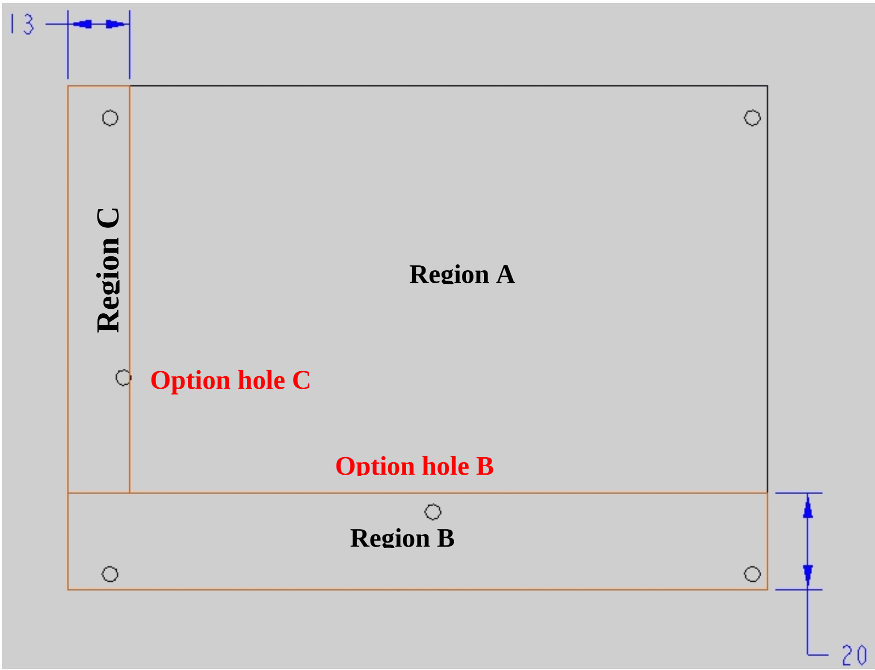


Table 5. Region Mapping Dedicated Usage

Region	Usage
A	Dedicated mainly to key components (processor, chipsets, LAN, FWH, etc.)
B	Dedicated mainly to rear I/O connector interfaces
C	Dedicated to expansion. Several signal group options have been defined (see Table 6).

Table 6. Region C Option Types

C Region	Signal Groups
Type I	Open definition
Type II	Four x 1 PCI Express
Type III	LPC, PCI, SDVO and one x 1 PCI Express

While the base board meets the minimal embedded application needs, the rich I/O interconnects available through the Region C expansion area facilitate extending the SBC's functionality to meet the demands of a variety of market segments.

The option types in Region C can be characterized as follows:

- Type I is defined as open to meet the customization needs of a particular application. Platform designers can use the expansion from Region C together with the Type I option to address individual system requirements.
- Type II is defined with four x 1 PCI Express interconnects to provide for the expansion capacity required, for example, by small form factor LAN appliances.
- Type III is defined for compatibility with legacy applications. Type III also provides one x 1 PCI Express interface to facilitate platform migration from a legacy platform product to a next generation PCI Express-based platform.

Secondary (Bottom) Side

The board's secondary side is not defined to specification. Feature or component placement on the secondary side will be user-defined. However, secondary side component ball out and pin out should not be sited beneath major components on the primary side.

Expansion Board

An expansion board is not defined to specification, to allow for greater flexibility in meeting embedded application requirements for different I/O types.

The expansion board should be able to be mounted on the base board and connected through an expansion slot in the designated zone area, Region C.

The total stack-up of the expansion board and the components on the expansion board, the base board, and the maximum component height limit, should be within either the height limit of 1 DIN or 2 DINs, as specified in the following section.

The option holes in Region B and Region C can be used to provide mechanical support for the expansion board.

4.3 System Level Z-Height Stack-up

The following are the Z-height stack-up specifications for different chassis. A is the chassis height, and B is the distance from the chassis to the bottom side of PCB.

Note: Figure 5 below is shown only for illustration purposes. Actual I/O configurations may differ.

Note: The expansion connector is not defined to specification. The specification leaves this to board designers.

Note: DIN height throughout this document is defined as 1 DIN=50 mm, 2 DINs=100 mm.

Figure 5. Maximum Z-Height Dimensions

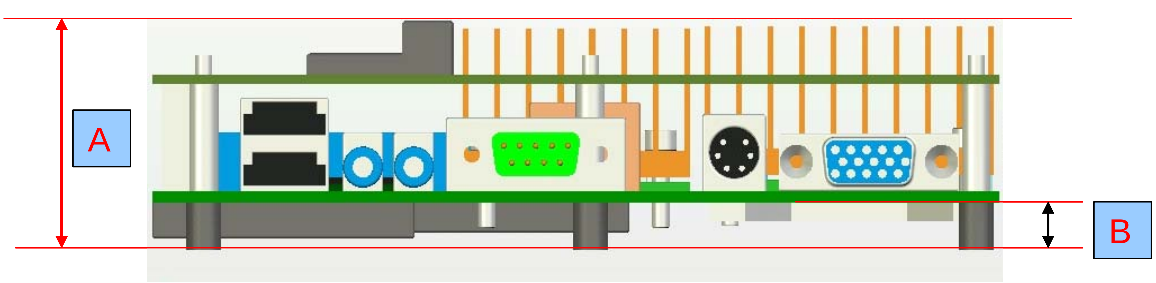


Table 7. Maximum Z-Height Dimensions

	A	B
1 DIN	50.0 mm	8.0 mm
2 DIN	100.0 mm	8.0 mm

4.4 Chassis Mounting

The chassis mounting feature should follow the mounting hole locations defined in Section 4.1. The mounting features on the chassis should provide an M3 threaded hole.

4.5 Electrical Power

Electrical power is not defined to specification in order to accommodate different application requirements. An adapter, ATX power supply, or other customization can be used. Board designers are required to calculate the power consumption for the board. Different silicon or processor generation will require different electrical power consumption. Electrical power calculation should include but is not limited to the processor, chipsets, RAM, expansion components, and I/O peripherals. Please refer to the respective component datasheet for details.

4.6 Thermal Power

The total thermal power dissipation should be within the limits of the thermal solution designed for the SBC system, which includes but is not limited to the microprocessor, chipsets, RAM, voltage regulator, and other heat generating system components.

Power dissipated from the processor, memory controller hub, and I/O controller hub should be based on the TDP defined in the respective product datasheet.

5 Proof-of-Concept Board – Silverdome

This section describes a proof-of-concept (POC) board developed by Intel and based on the Intel® ECX Form Factor specification. To better illustrate the field application of a small form factor SBC, the I/O configuration of the POC board was pre-defined based on feedback from an example market segment, in this case an on-vehicle infotainment system.

Figure 6. Proof-of-Concept Board in System Solution

The POC system solution demonstrates the Intel® ECX Form Factor's small size and rich I/O interfaces, although it does not reflect actual end-use product requirements and finishing, which would be left to system integrators and board vendors.

5.1 Proof-of-Concept Board Overview

Figure 7. Proof-of-Concept Base Board

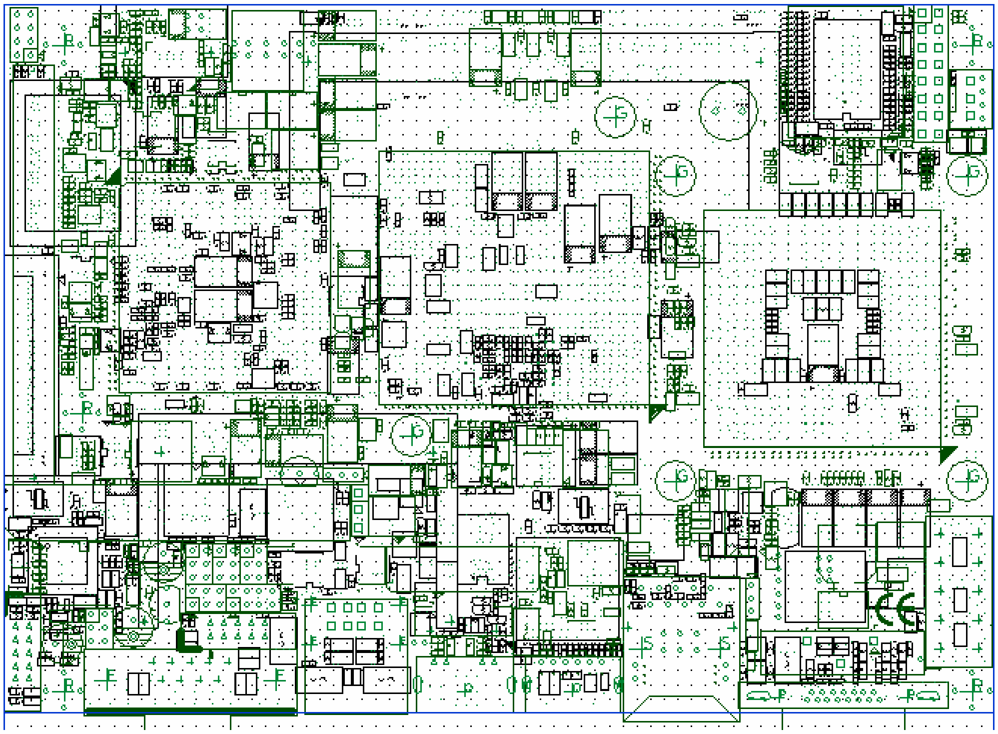
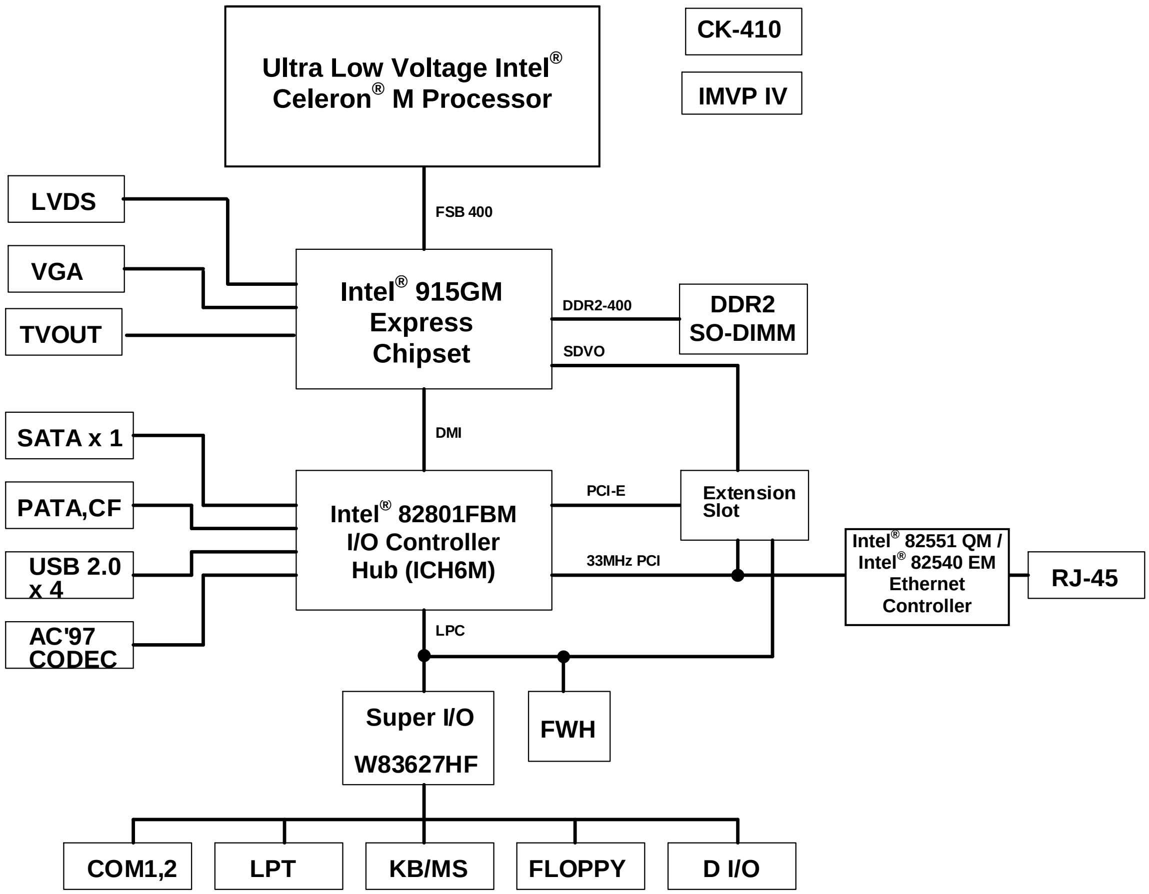


Figure 8. Silverdome POC Board

5.2 Proof-of-Concept Platform Block Diagram

Figure 9. Silverdome POC Platform Block Diagram



5.3 Proof-of-Concept Board Specifications

Table 8. Proof-of-Concept Board Specifications

Components		Description
Board	Dimension (L x W)	146 mm x 105 mm
	Stack-up	10 layers
Processor	CPU Type	Ultra Low Voltage Intel® Celeron® M Processor
	CPU Package	478 Micro Flip Chip Ball Grid Array (Micro-FCBGA)
Chipset and Memory	System Chipset	915GM / ICH6M
	Max. Memory	256/512 MBytes
	Memory Type	DDR2 SO-DIMM
Display	VGA	1 x
	LVDS	1 x
	TV-out	1 x
I/O Peripherals	Audio	AC’97
	LAN	10/100 Mbps
	Serial	• 1 x RS232 on DIP port • 1 x RS232/485/422 on pins header
	USB	• 2 x USB on ports • 2 x USB on pins header
	Keyboard/Mouse	1 x PS/2
Storage	IDE	1 x Disk and CD-ROM
	SATA	1 x Disk
	Compact Flash	1 x (Type I/II)
Management	Watchdog Timer	By seconds / minutes
	Power Management	ACPI
	Power Requirements	12/5/3 Volts
Other	Mini PCI Type 3-B	Through expansion board
	Expansion Bus	PCI x 2 master, LPC, SDVO, PCI Express x 1 Link

5.4 Proof-of-Concept Board Layout Placement

Figure 10. Primary Side Layout Placement

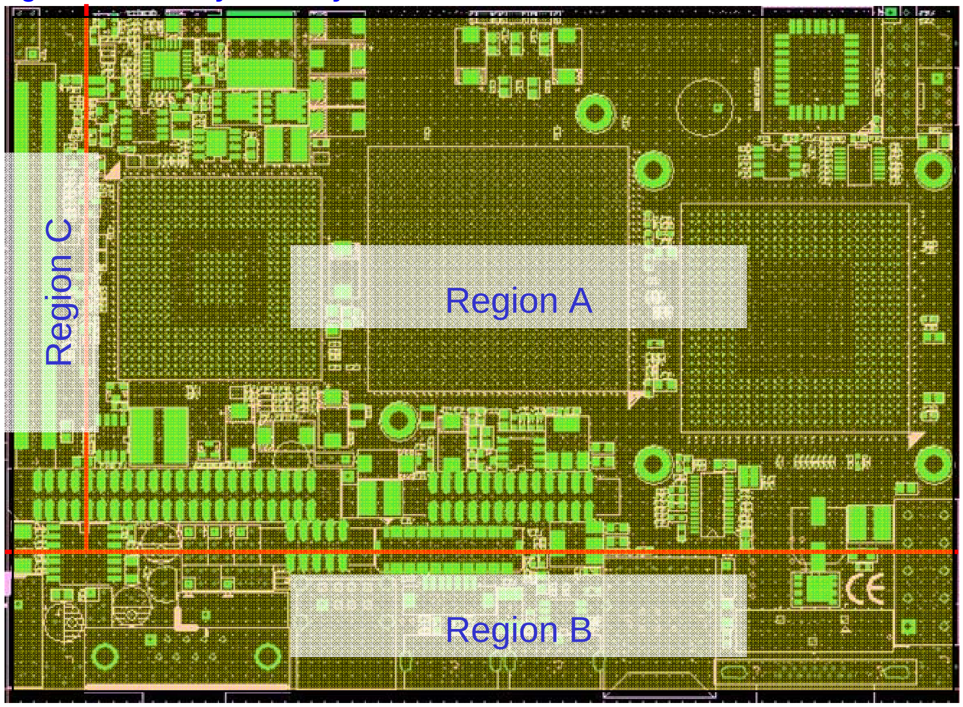
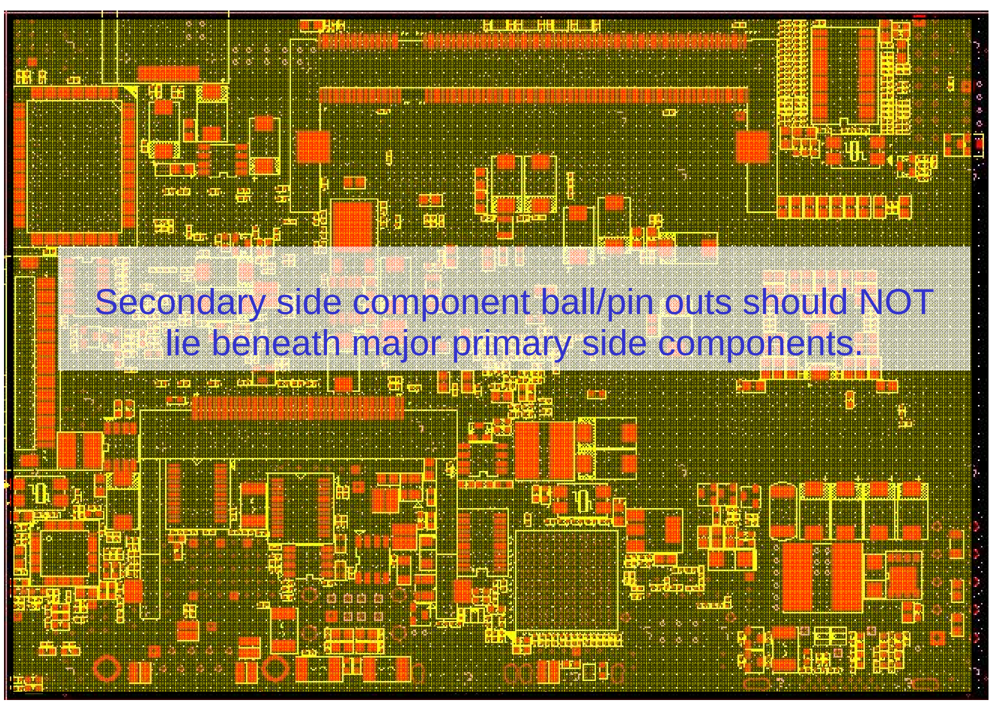


Figure 11. Secondary Side Layout Placement



5.5 Proof-of-Concept PCB Stack-up

Figure 12. Proof-of-Concept PCB Stack-up

L1	H oz	Signal
L2	1oz	GND
L3	1 oz	Signal
L4	1 oz	Signal
L5	1oz	GND
L6	1 oz	POWER
L7	1 oz	Signal
L8	1 oz	Signal
L9	1 oz	GND
L10	H oz	Signal

5.6 Proof-of-Concept Board Thermal Solution vs. Environment Conditions

The proof-of-concept board takes a natural convection approach to heat dissipation, using a heat sink solution attached to the processor and MCH. The heat sink solution for the ICH will be dependent on the solution space remaining (as constrained by the expansion card), and will be available in a wide range of off-the-shelf solutions by industrial thermal solution vendors. The heat sink z-height when mounted to the package or board meets the specification of 1 DIN (50 mm) system height. Please refer to the Intel® ECX Form Factor *Thermal Design Guide* for further details.